Geophysical Research Abstracts,
Vol. 11, EGU2009-9274-1, 2009
EGU General Assembly 2009

Deterministic and stochastic modifications of the Stokes formula

A. Ellmann

Tallinn University of Technology, Dept. of Civil Engineering, Tallinn, Estonia (artu.ellmann@ttu.ee, +372 620 2601)

Several recent space technologies have improved our knowledge of the global gravity field and Earth's topography. However, the space-borne data is not only limited by its accuracy but also by the spatial resolution. For instance, the ongoing satellite gravimetric mission GRACE has resolved the long-wavelength component of the global geoid with an accuracy of a few cm, whilst the spatial resolution of such information is limited to about 200 km. Even though the first satellite gradiometry mission GOCE (to be launched by the European Space Agency in 2009) will be capable to further enhance the intermediate wavelength information of the gravity field, but only up to the 65 km spatial resolution. Further improvements to the Earth gravity models (EGM) at shorter wavelengths should still come from the use of terrestrial surveys and satellite altimetry (over the oceans). The resolution of a new combined EGM08 is 5´ arc-minutes (corresponding to 9 km, i.e. to the spectral degree of 2160). For many applications, however, the resolution of the EGM08 may not be sufficient. For solving a large variety of engineering tasks a high-resolution (2-3 km) regional geoid model with an 1 cm accuracy is required. Obviously, due to tremendous computational burden and the voids of terrestrial gravity data it is unrealistic to develop such an ultra-high-degree spectral model of the global geoid. Therefore, the usage of the local terrestrial data is still requested for the the high-resolution regional geoid modeling.

Regional improvements of global geoid models can be obtained by modifying Stokes's integral formula. This method combines an appropriate EGM spectrum with local terrestrial data in a truncated Stokes's integral. The integral argument is usually a residual gravity anomaly, which is obtained by subtracting the EGM derived long-wavelength contribution from the complete gravity anomaly. This contribution focuses on the integral part of the formula, which generates short wavelenght features for regional geoid model. Over recent decades two distinct groups of modification approaches - deterministic and stochastic, have been proposed in geodetic literature. The deterministic approaches principally aim at reducing the truncation bias (caused by neglecting of the remote zone) only, whereas the stochastic methods attempt also to incorporate the accuracy estimates of EGM's geopotential coefficients and terrestrial data. Both groups employ a modified Stokes function as the integral kernel for the near-zone integration.

The selection of the upper modification limit is directly related to the quality of the EGM to be used. In practice, due to restricted access to terrestrial data the integration radius is often limited to a few hundred kilometres. This implies that a relatively high modification degree should counterbalance this limitation. On the other hand, the EGM error grows with increasing degree, which provides a rationale for choosing a compromise modification limit. Due to poor accuracy of the earlier EGM-s a rather small modification degree was favoured in the computations of many geoid models in the past. Importantly, the space technology advancements have significantly improved the accuracy of recent EGM-s, which allows the user to safely increase the modification degree (up to 100 or even beyond). However, certain difficulties may be encountered when determining (usually, from a system of linear equations) the modification parameters. The solution may become numerically unstable when a small integration cap and/or high modification degree is adopted for computations. Accordingly, this contribution revisits the principles of choosing the appropriate modification method in the context of contemporary EGM-s. Also the strategies for selecting appropriate modification limits are revisited. Typical and optimum outcomes of the modifications are discussed.